IONIZING RADIATION HAZARDS ON THE MOON
(characterizing the lunar radiation environment)

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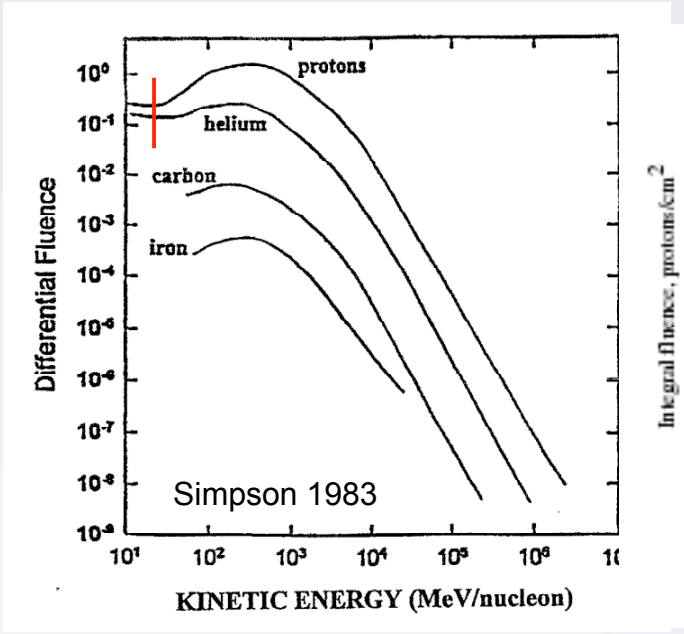
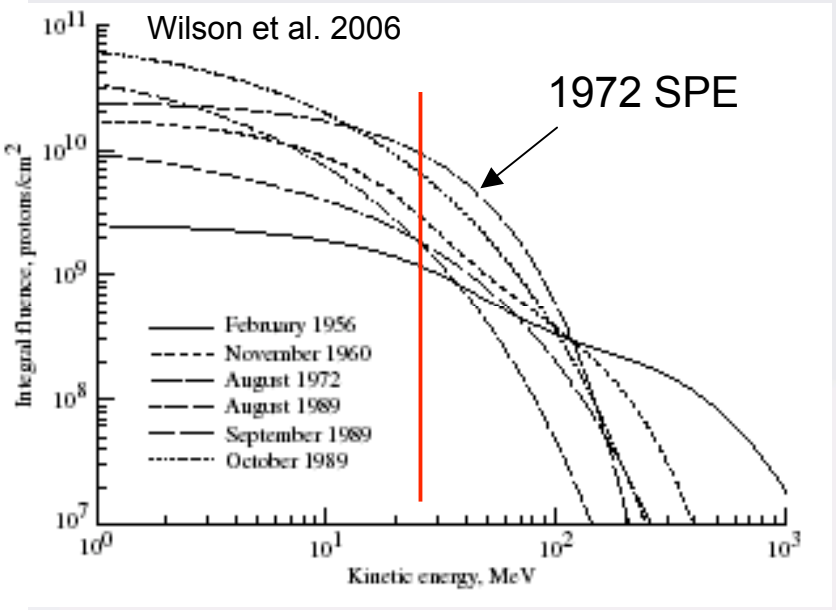
Space Radiation Environment

Galactic Cosmic Radiation

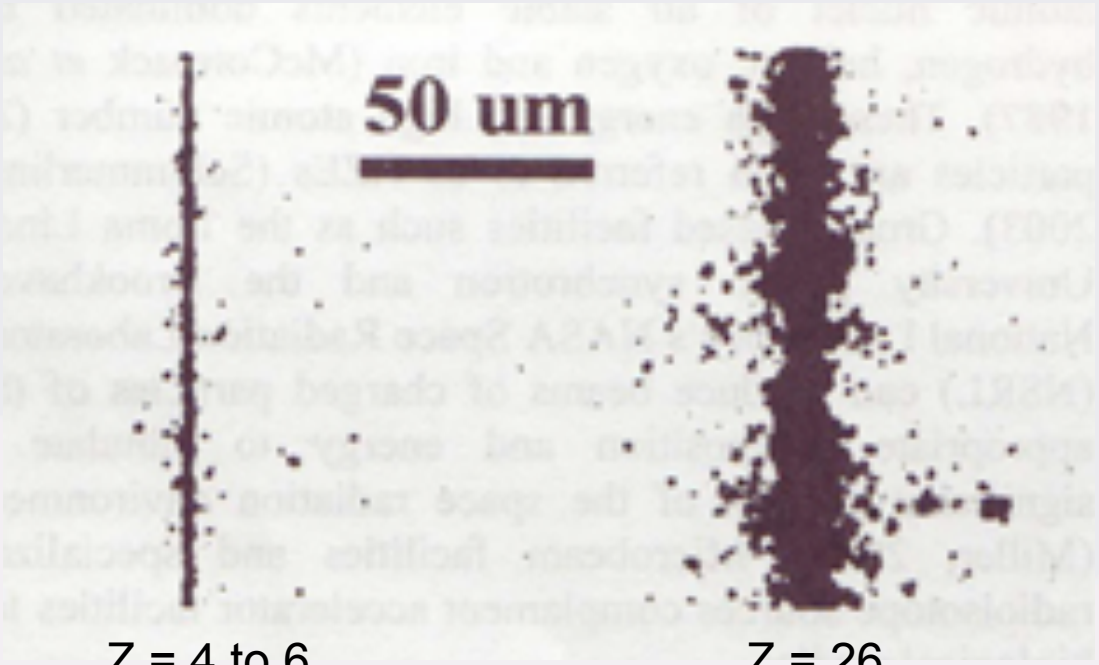


Solar Particle Event Protons



-Secondary radiations are produced in lunar surface, e.g., neutrons
-Lunar topography is also important

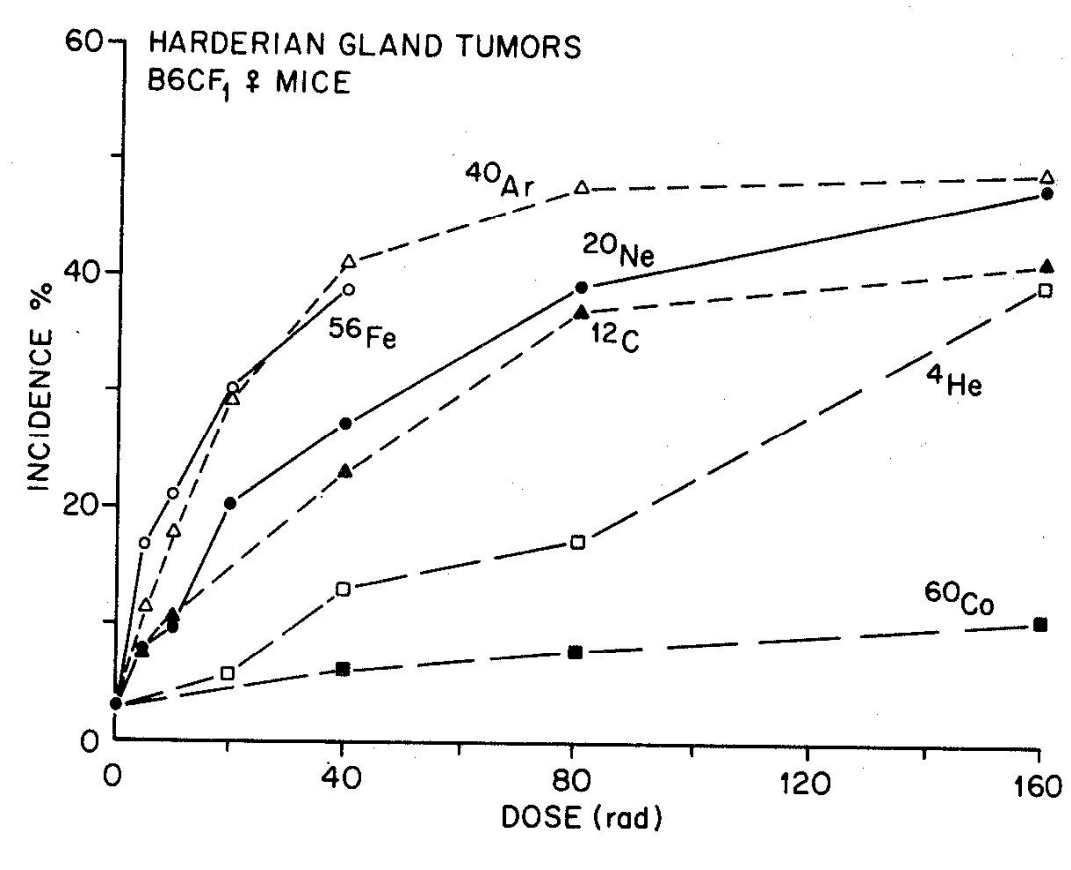
Radiation Particle Tracks



Z = 4 to 6 Z = 26

Charged particle tracks in photographic emulsion from Apollo-8
(Schaefer and Sullivan 1976)

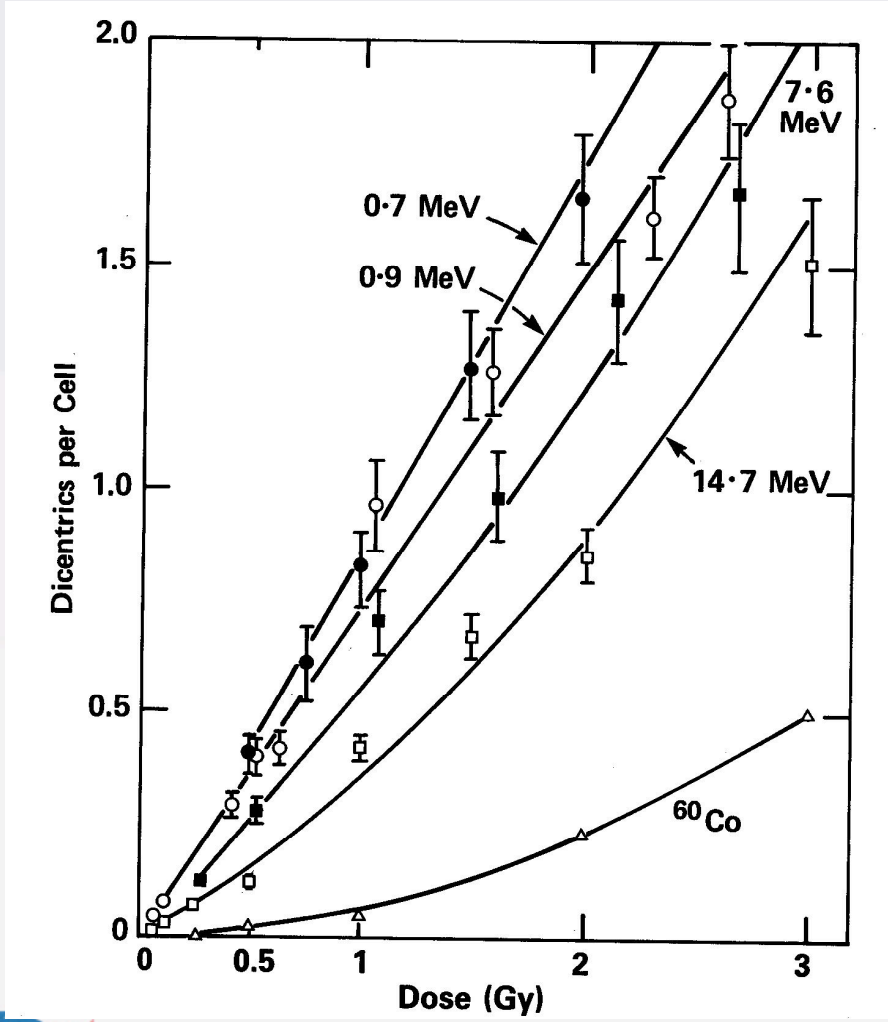
Relative Hazard of Charged Particles



Fry et al. 1985

- **Heavy nuclei >> light nuclei > gammas**
- **But, radiobiology data show large inter-system differences**

Relative Hazard of Neutrons

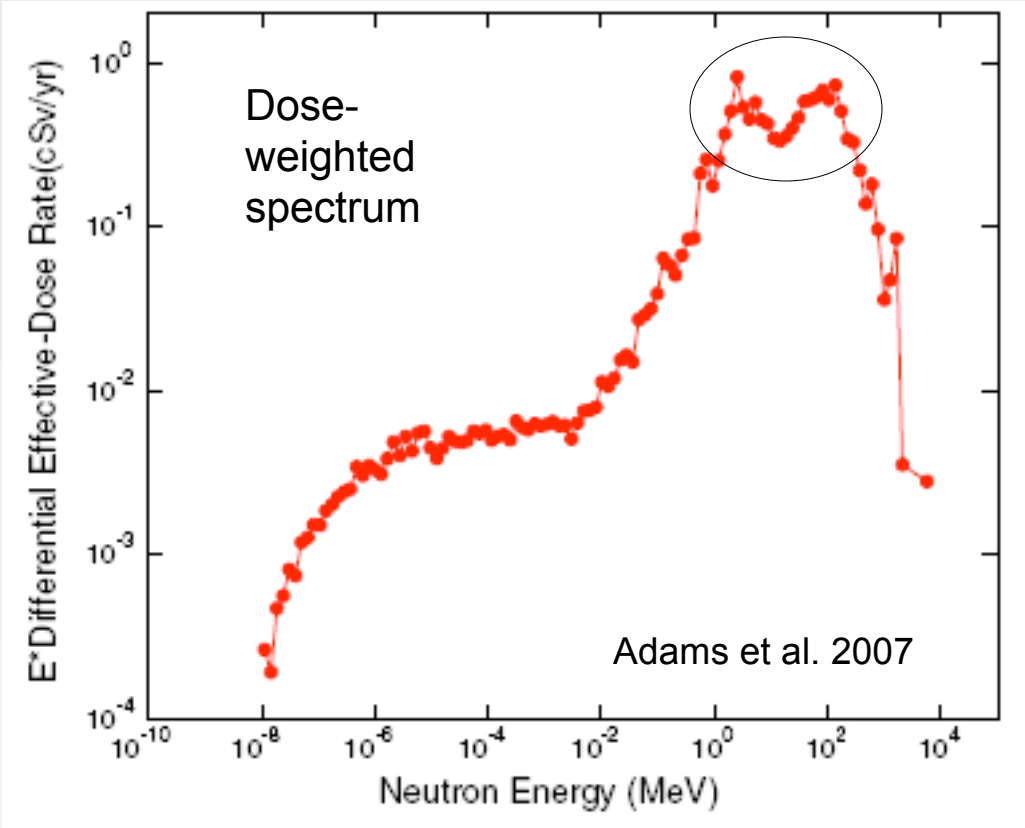


- **Chromosome aberrations in human lymphocytes (*in vitro*)**
- **Effect increases with decreasing neutron energy**
- **Sparse data above 15 MeV**

Lloyd et al. 1976

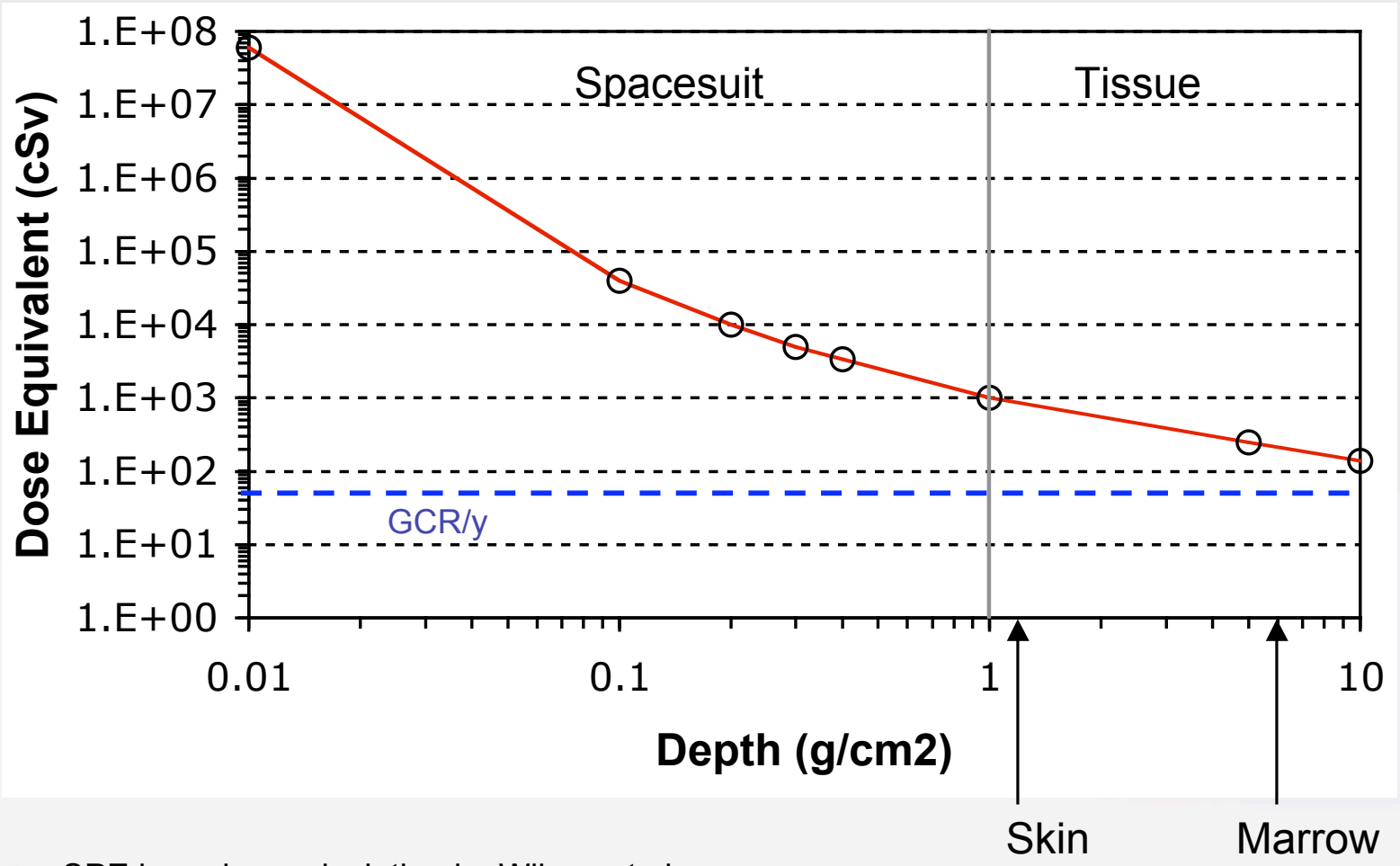
Lunar Albedo Neutrons

(Based on Lunar Prospector Measurements)



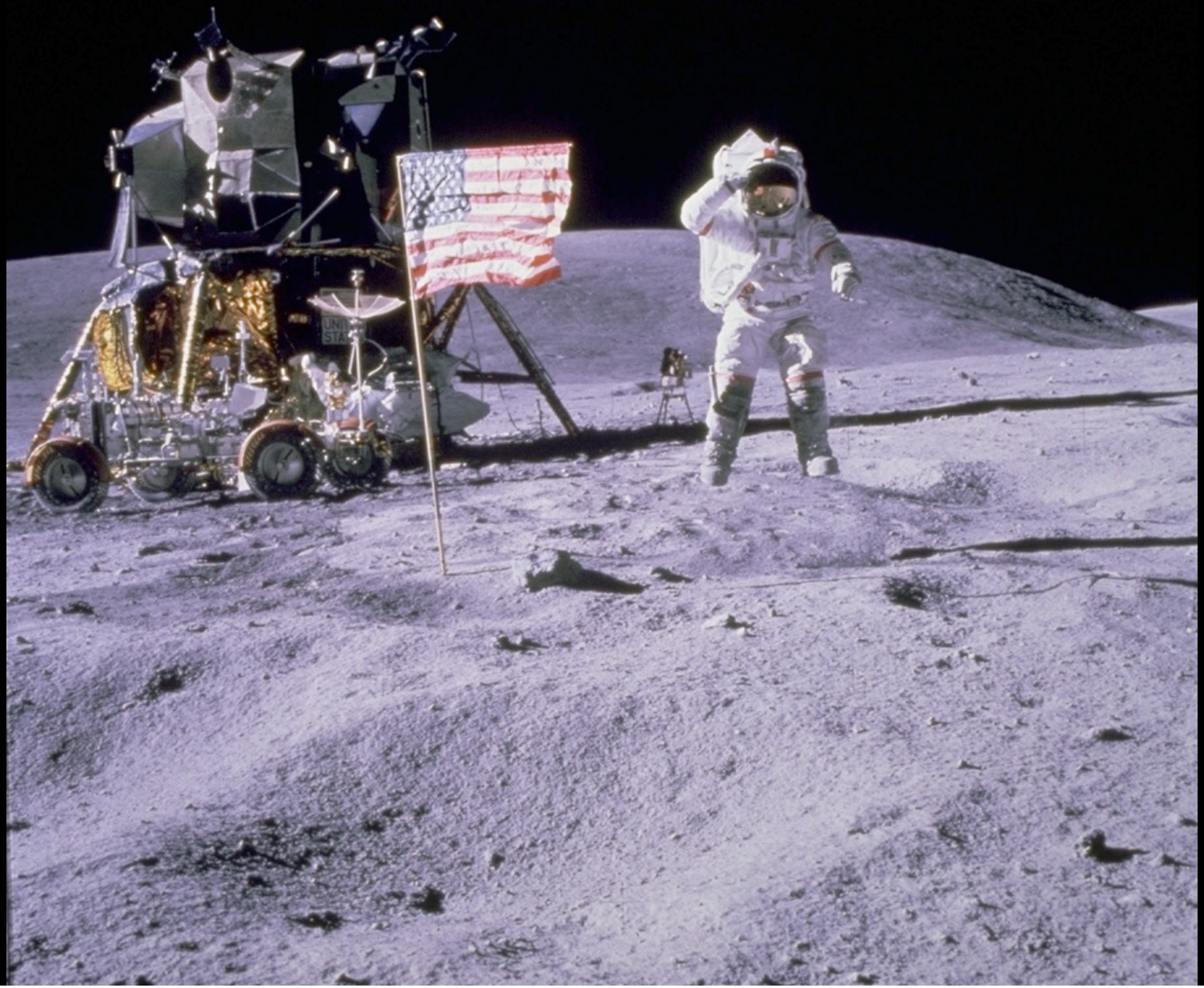
- **Maximum ~2 MeV**
- **High RBE**
- **LRO improvements?**
- **Problem for Mars RAD?**

Very Steep Depth Dose Profile
(Based on Aug 72 SPE)



SPE based on calculation by Wilson et al 2006, 1 AU, free space

GCR and SCR are Recorded in Lunar Regolith

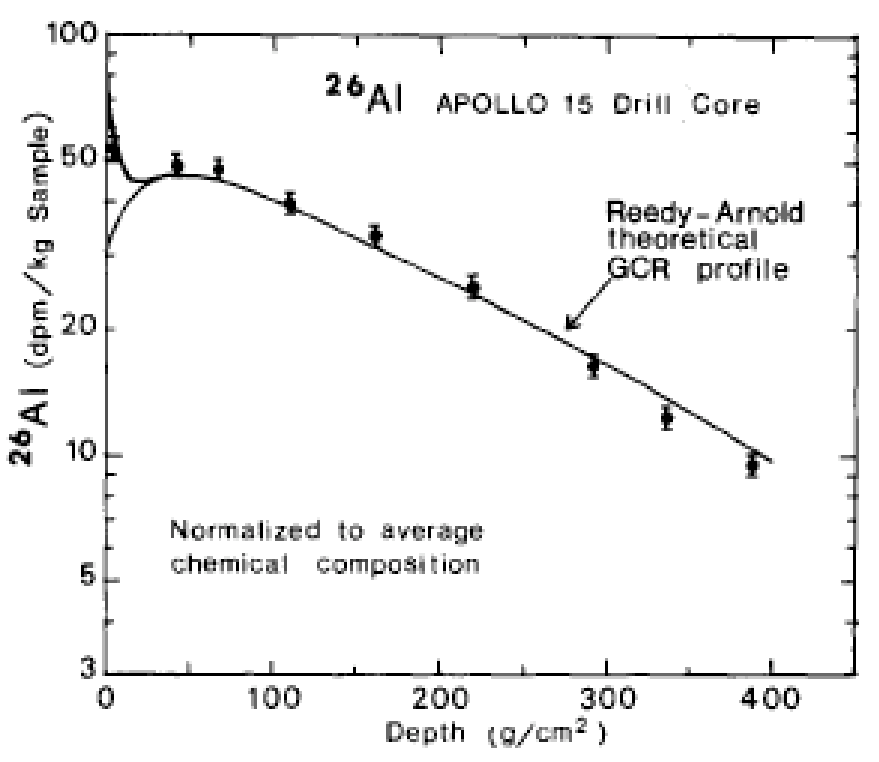


Record Can Provide Important Info

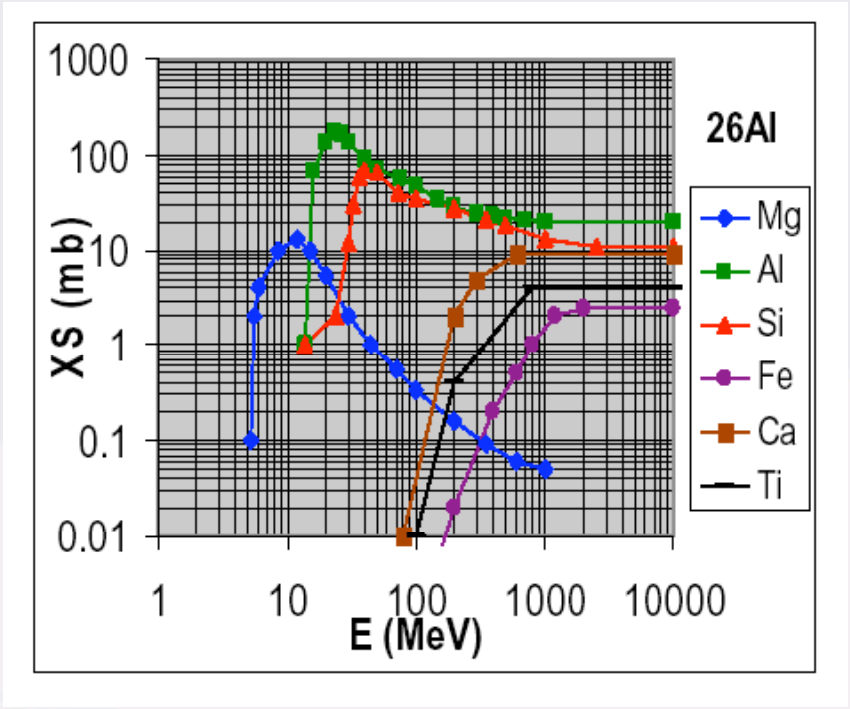
- Geochronology
- Surface remodeling
- GCR and SCR diagnostics (energy, flux, temporal trends)
- Regolith shielding characteristics
- Dosimetry
- Etc…

GCR Profile (Al-26)

Half-life ^{26}Al = 705,000 y

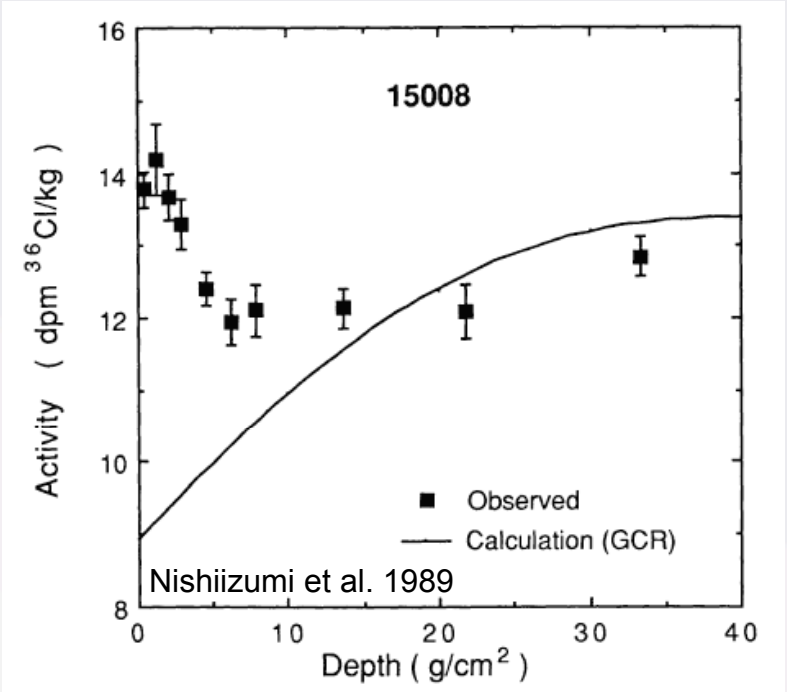


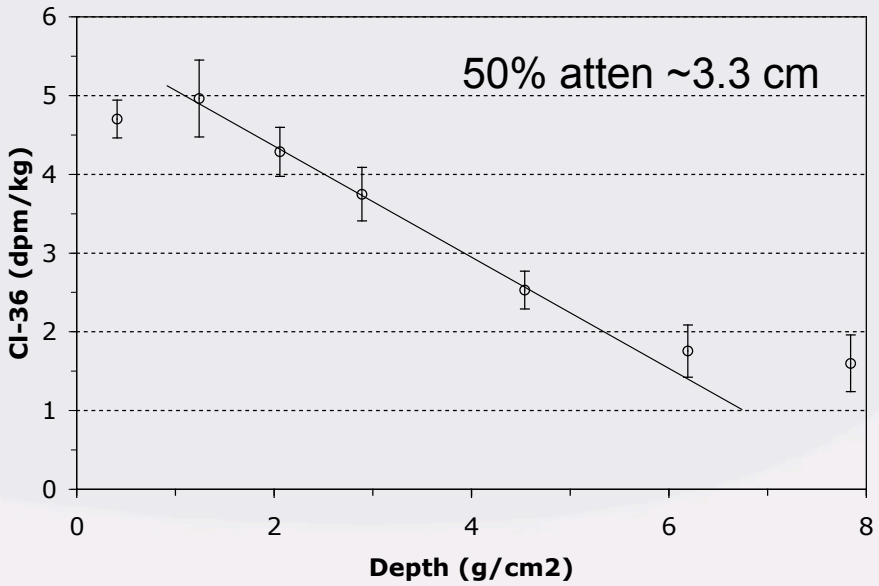
Nishiizumi et al. 1984



Proton cross-sections that produce ^{26}Al (Reedy 2007)

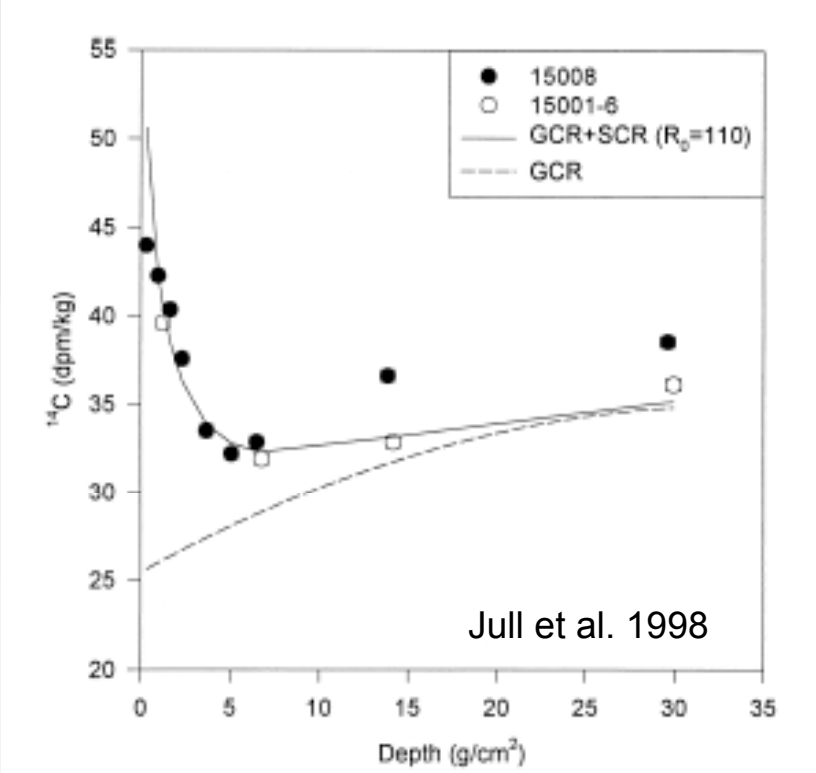
SCR Profiles (Cl-36)

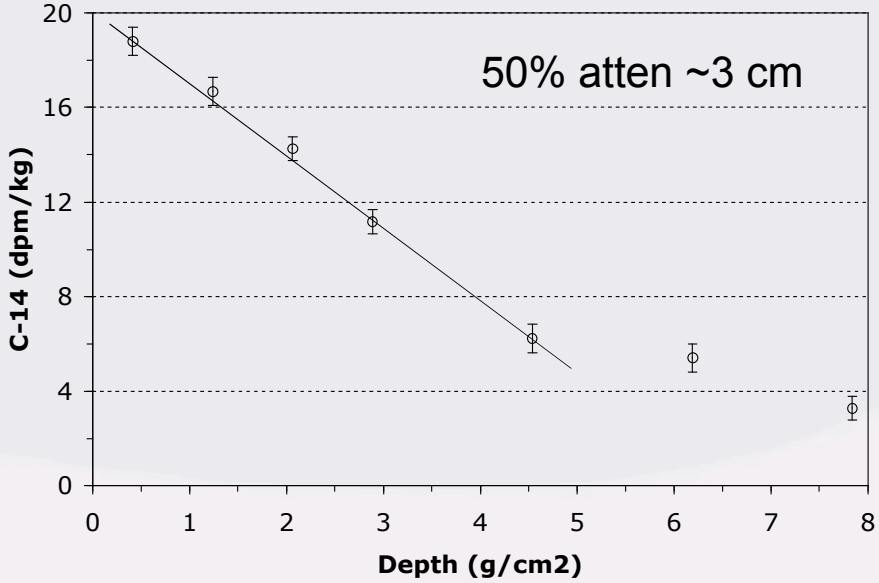




Half-life ^{36}Cl = 301,000 y

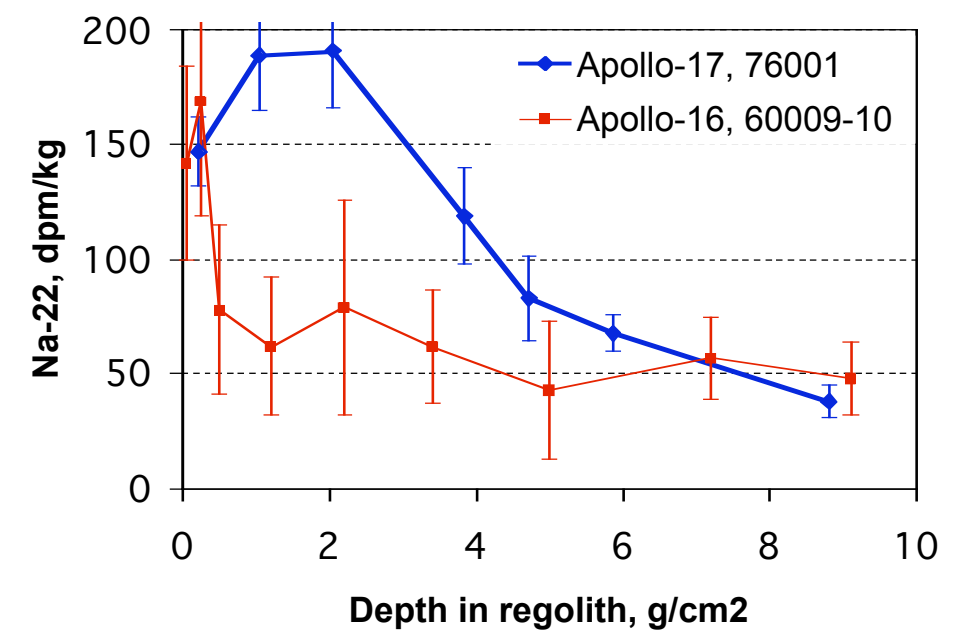
SCR Profiles (C-14)

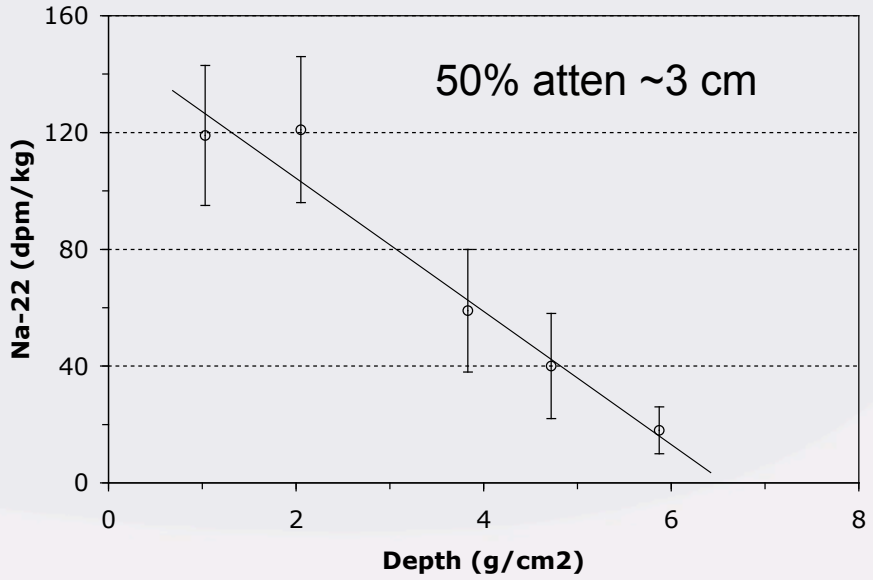




Half-life ^{14}C = 5730 y

Can We See the Aug 72 SPE?
(Delta between Apollo-16 & 17 cores)





Data sources (drive tubes only):

- Apollo-16 (Apr 16, 1972); data from Fruchter et al. 1977
- Apollo-17(Dec 7, 1972); data from Evans et al. 1980

Half-life ^{22}Na = 2.6 y